View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by CORE

Wright State University

CORE Scholar

International Symposium on Aviation Psychology - 2015

International Symposium on Aviation Psychology

2015

Individual Problem Representations in Distributed Work

Alicia Fernandes

Philip J. Smith

Ken Durham

Mark Evans

Follow this and additional works at: https://corescholar.libraries.wright.edu/isap_2015

Part of the Other Psychiatry and Psychology Commons

Repository Citation

Fernandes, A., Smith, P. J., Durham, K., & Evans, M. (2015). Individual Problem Representations in Distributed Work. *18th International Symposium on Aviation Psychology*, 336-341.
https://corescholar.libraries.wright.edu/isap_2015/50

This Article is brought to you for free and open access by the International Symposium on Aviation Psychology at CORE Scholar. It has been accepted for inclusion in International Symposium on Aviation Psychology - 2015 by an authorized administrator of CORE Scholar. For more information, please contact library-corescholar@wright.edu.

INDIVIDUAL PROBLEM REPRESENTATIONS IN DISTRIBUTED WORK

Alicia Fernandes, Philip J. Smith, Ken Durham, and Mark Evans
The Ohio State University
Columbus, OH

Human-machine interfaces in distributed work systems provide external problem representations that activate the cognitive processes people use to perform their work. Appropriate design of such representations is an important factor in supporting complex work. In air and surface traffic management, problems are typically framed according to airspace constraints even for practitioners whose domain is the airport surface. Constraints are passed from the en route and terminal domains to the surface in the form of airspace constraints, with the displays available to Air Traffic Control Tower (ATCT) personnel communicating these constraints in airspace terms. However, ATCT personnel use a different mental model to manage departures. An exploratory study found that ATCT personnel very quickly transform airspace-centric constraints into surface-centric constraints, while still discussing the constraints with en route and terminal traffic managers using airspace-centric terms. They must continually perform such transformations due to the representation of the information provided to them.

External problem representations provided to agents in a distributed work system activate the cognitive processes practitioners use to reason about, and ultimately decide upon a solution to, a given problem (Smith, McCoy, & Layton, 1997; Zhang & Norman, 1994). While external problem representations are not necessarily re-created internally by the problem solver, they strongly influence the internal representation used to perform cognitive work and the way in which the practitioner frames the problem at hand. When engaging in coordinated activities, practitioners use these external representations as forms of communication. External representations that are incongruous with practitioners' cognitive work, however, may still prove useful as tools for sharing problem representations in a distributed work environment.

Air traffic managers often address airspace constraints by invoking initiatives that reduce traffic flows through the affected airspace. Such initiatives often take the form of Miles In Trail (MIT) restrictions, defining the longitudinal separation required between two aircraft operating on the affected route. When en route airspace is constrained, the Air Route Traffic Control Center (ARTCC) determines the MIT required to manage affected traffic and is likely to "pass back" the MIT constraint to any Terminal Radar Approach Control (TRACON) handing off aircraft to the ARTCC airspace. For example, "WAVEY 25MIT 1900-2200 ZNY:N90" indicates that the New York ARTCC (ZNY) requires the New York TRACON (N90) to provide 25 miles between any two aircraft using the WAVEY departure fix from 1900Z to 2200Z.

The TRACON, in turn, passes back the constraint to the Air Traffic Control Tower (ATCT). However, the TRACON uses a different separation standard than the ARTCC during normal operations (3 miles versus 5 miles), and so the TRACON may pass back a different MIT restriction for affected aircraft at the first radar hit upon takeoff (e.g., 15 MIT off the ground).

ATCT controllers have to ensure that restricted aircraft have the appropriate separation upon takeoff and try to avoid delaying them more than necessary to achieve the restriction.

Furthermore, these aircraft share departure runways with aircraft that may not be restricted (i.e., aircraft using different routes). ATCT controllers need to stage departures such that they can maximize runway throughput while minimizing the delay experienced by any one aircraft. This paper describes an exploratory study that identified departure management strategies used by ATCT controllers in the face of dynamic weather-related constraints.

Method

Structured interviews were performed with retired ATCT controllers and Traffic Management Coordinators (TMCs) who walked through a dynamic weather scenario and shared the strategies they would use to manage departures on the surface of a hypothetical airport.

Participants

Twelve recently retired ground controllers and TMCs with an average of 23.4 years of experience at busy facilities participated. Eight participants had formal experience as a TMC and 2 had unofficial experience as a TMC (such as filling in while a TMC was on vacation). Four participants had formal experience as an ATCT supervisor and 3 had unofficial experience as an ATCT supervisor. In addition, 7 had worked as TRACON controllers, 2 had worked as ARTCC controllers, 1 had worked as a flight service specialist, and one had worked for 15 years as an Air Traffic Control System Command Center (ATCSCC) traffic management specialist.

Major Airport (MJA)

This study used a hypothetical airport, Major Airport (MJA), shown in Figure 1. The study scenario involved departures from runways 18C and 18L. Note that 18C has two parallel taxiways and 18L has only one. MJA was embedded in the Collaborative Airport Traffic System, known as CATS (Fernandes, Smith, Spencer, Wiley, & Johnson, 2011).

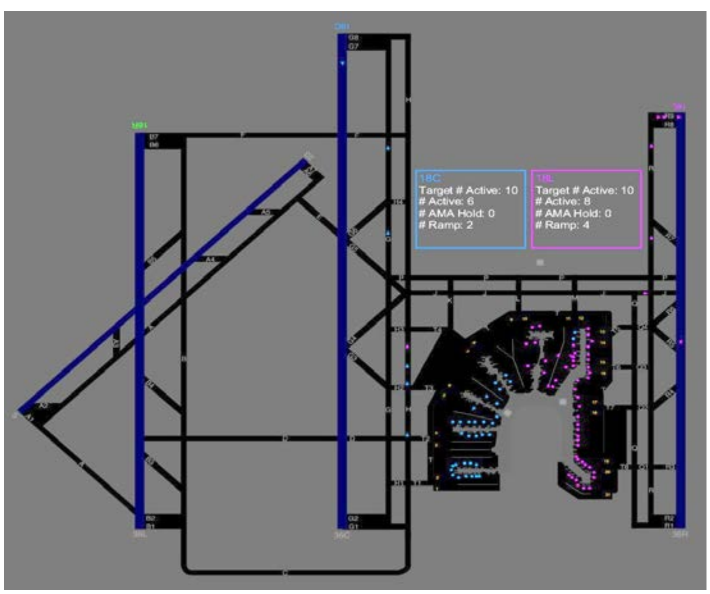

Figure 1. Layout of hypothetical airport used in the study

Simulation Scenario

The weather scenario consisted of actual current and forecast weather from July 26, 2010, in the Dallas, TX area. The researcher walked through the weather scenario from 1500Z to 0000Z, stopping every 30 minutes to allow the participant to view the two-hour forecast in 15-minute increments. At each 30-minute increment, the participant was asked about the surface management strategies they thought they would use in response to the weather. Then the participant was shown the current list of departure restrictions (generated by ARTCC and TRACON air traffic managers in a previous structured interview) and asked whether that information would impact their surface management strategy. The participant also would be shown the scheduled demand over the coming 30-60 minutes. For example, at 1800Z the participant would have access to displays similar to those shown in Figure 2.

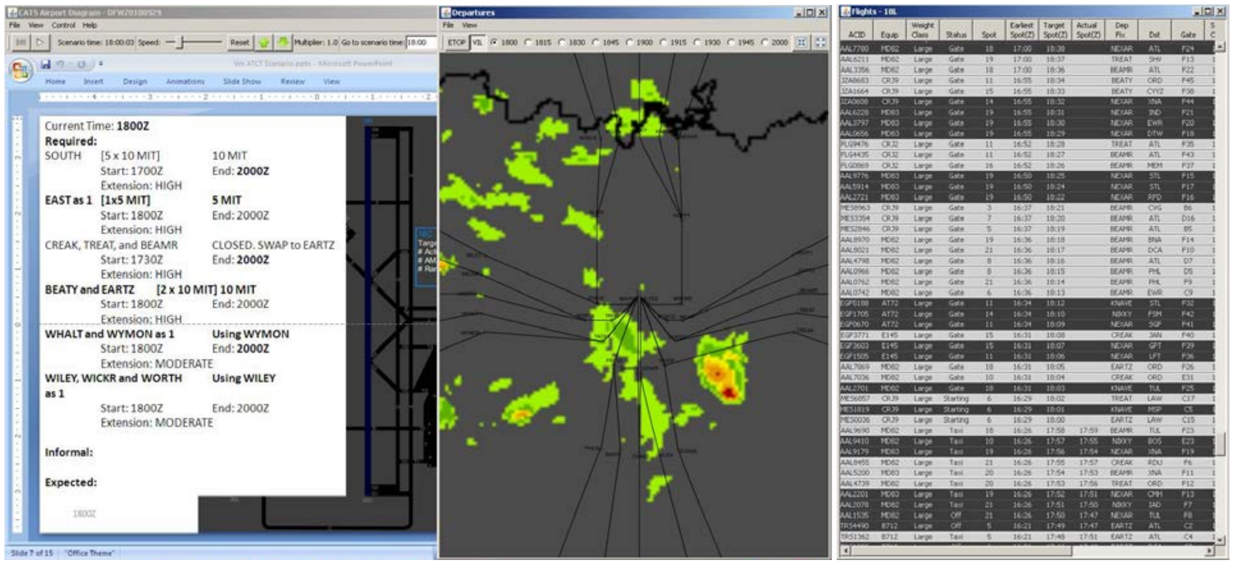

Figure 2. Displays similar to those shown to participants at 1800Z

Figure 2 shows the departure restrictions in place at 1800Z. Restrictions that had changed since 1730Z are shown in boldface. The list of departure restrictions is super-imposed over a map of the hypothetical airport. Participants were shown a map with no aircraft on it to try to avoid biasing their thinking in determining a surface management strategy. Participants also were able to see a list of aircraft already taxiing and scheduled to enter the movement area over the coming 30-45 minutes. In Figure 2, aircraft scheduled to depart to the east are highlighted, enabling the participant to quickly assess the demand for eastbound departure fixes in developing a strategy for staging those aircraft for departure.

At each 30-minute interval, the researcher updated the simulated weather, departure schedule, and departure restrictions. The researcher asked the participant questions such as:

- How would you want to stage flights for each departure runway?
- How many flights would you want in the lineup for each departure runway?
- Do you see anything in the weather that would cause you to change your plan?

- Do you see anything in the updated departure route restrictions that would cause you to change your plan?

Participants described the strategy they would use for staging departures given the weather and departure restrictions. It was hypothesized that participants would consider the weather forecast and the scheduled departure demand in developing a surface management strategy. Participants also were expected to use the taxiways to segregate aircraft by departure fix and direction when there were restrictions in place. In particular, participants were expected to use taxiways G and H and run-up pads G-7 and G-8 to stage aircraft for runway 18C and run-up pads R-8 and R-9 to stage aircraft for departure from runway 18L (see Figure 1 above). Thus, with two taxiways available for runway 18C and only one taxiway for runway 18L, participants were expected to use different strategies for staging departures for the two runways.

Results

Despite the difference in taxiway structure for the two runways, participants used similar strategies to stage departures for each runway. However, they expressed that they had greater flexibility in staging departures for 18C because it had two taxiways as well as an intersection at F from which any aircraft in the scenario could depart if and when it would be advantageous to do so. In addition, the surface management strategies were not so different when there were departure restrictions in place than when there were no departure restrictions. Due to space limitations, only strategies used for assigning taxiways and sequencing departures for runway 18C to accommodate the departure restrictions at 1800Z are discussed here.

At 1800Z, each of the southbound departure fixes had a 10 MIT restriction. Westbound routes Whalt and Wymon would be treated as one route and westbound routes Wiley, Wickr, and Worth would also be treated as one route until 2000Z. All northbound routes were open with no restrictions.

Six participants said they would assign flights to taxiways according to departure fix. Three of these said they would separate taxiways by effective route (i.e., departure fixes Wiley, Worth and Wickr on one taxiway and departure fixes Whalt and Wymon on the other). The other three said they would assign all westbound flights to one taxiway and all “splitters” to the other. “Splitters” is an ATCT term for unrestricted departures sequenced between restricted departures to achieve the required MIT. An important consideration in building a departure queue is the number of splitters to include.

The number of splitters an ATCT controller uses to meet an MIT restriction is an external representation of the translation they mentally perform when presented with the airspace-centric restriction. Participants were asked how they determine the number of splitters to use between any two aircraft subject to a 10, 15, or 20 MIT restriction. Their responses are shown in Figure 3. One participant said, “6,000 feet [and airborne] will get you 2 ½ to 3 miles, you’ve got 3, 6, 9 miles,” referring to the minimum separation requirement for departures whose headings diverge by at least 15 degrees (FAA, 2014).

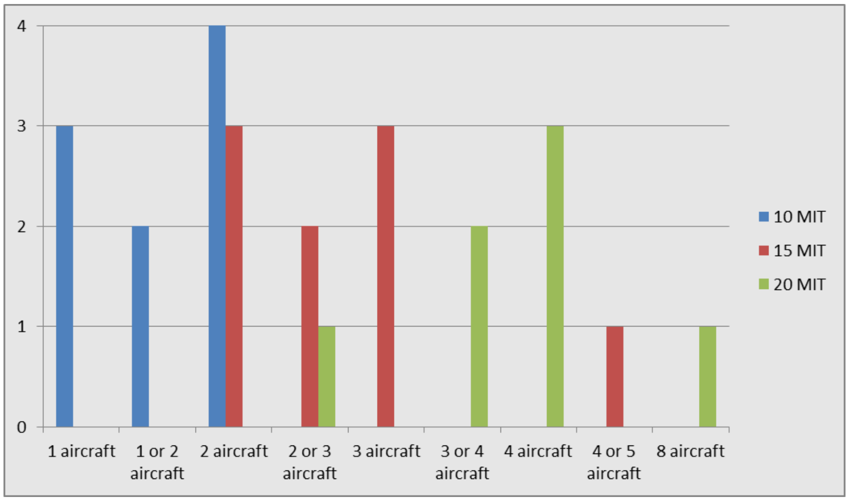

Figure 3. Number of splitters between aircraft subject to 10, 15, or 20 MIT

Some of the participants said they would vary their strategy by aircraft type, but their overriding concern was ensuring that they provided no more than the required MIT because that would represent wasted capacity. One participant said that controllers “don’t want to provide any more than that number because if you provide more than that number then you’re probably self-imposed restrictions and it’s not a good thing. So you want to be right on the dot with that…”

Discussion

ATCT tools describe airspace constraints in terms of air route restrictions such as miles in trail, when in fact ATCT personnel transform these restrictions into surface management strategies involving departure staging locations, aircraft characteristics, and splitters. Such differences in problem representations have consequences for the design of tools to support airport surface management personnel in performing their work as well as supporting inter-facility coordination and collaboration throughout the NAS.

For example, ramp controllers stage aircraft leaving the ramp area in a way that they expect to be efficient for the ground controllers. However, they rarely have explicit information about the strategy the ground controllers are using and so may not actually stage departures in an efficient manner (Borgman & Smith, 2010). In addition, explicit representations of surface management strategy may support Surface Collaborative Decision Making (Fernandes, et al., 2012; FAA, 2013) and other decision support tools (Atkins, Churchill, & Capozzi, 2013; Brinton & Lent, 2012).

Acknowledgements

The FAA Human Factors Research & Engineering Group coordinated the research requirement, and its principal representative acquired, funded, and technically managed execution of the research service. In addition, the authors would like to thank Dr. Rich DeLaura of MIT Lincoln Laboratory, who provided the weather images from the Corridor Integrated Weather System (CIWS). The research was conducted as part of the first author’s doctoral dissertation.

References

Atkins, S. C., Churchill, A., & Capozzi, B. J. (2013). Sensitivity of NASA's Spot and Runway Departure Advisor to traffic forecast errors. *Aviation Technology, Integration, and Operations Conference.* Los Angeles, CA.

Borgman, A. D., & Smith, P. J. (2010). *The Integrated Management of Airport Surface and Airspace Constraints for Departures: An Observational Study of JFK, EWR, and IAH.* Columbus, OH: The Ohio State University Technical Report #CSEL 2010-09.

Brinton, C., & Lent, S. (2012). Departure queue management in the presence of traffic management initiatives. *2012 Integrated Communications Navigation and Surveillance (ICNS) Conference.* Herndon, VA.

FAA. (2013). *U.S. airport Surface Collaborative Decision Making (CDM) Concept of Operations (ConOps) in the near-term: Application of Surface CDM at United States airports.* Washington, DC: Federal Aviation Administration.

FAA. (2014). *Order JO7110.65V Air traffic control.* Federal Aviation Administration, Air Traffic Organization. Washington, DC: Department of Transportation.

Fernandes, A. B., Smith, P. J., Spencer, A., Wiley, E., & Johnson, D. (2011). Collaborative Airport Traffic System (CATS) to evaluate design requirements for an airport surface departure management system. *Proceedings of the 55th Annual Meeting of the Human Factors and Ergonomics Society.* Las Vegas, NV.

Fernandes, A. B., Smith, P. J., Weaver, K., Durham, K., Evans, M., & Johnson, D. (2012). Identifying support requirements for airport departure management. *Proceedings of the 56th Annual Meeting of the Human Factors and Ergonomics Society.* Boston, MA.

Smith, P. J., McCoy, C. E., & Layton, C. (1997). Brittleness in the design of cooperative problem-solving systems: The effects on user performance. *IEEE Transactions on Systems, Man and Cybernetics, 27*, 360-370.

Zhang, J., & Norman, D. A. (1994). Representations in distributed cognitive tasks. *Cognitive Science, 18*, 87-122.